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INQUIRY BASED LEARNING WITH FORMATIVE ASSESMENT FEEDBACK TO INCREASE CRITICAL THINKING SKILLS AND CHEMICAL CONCEPT UNDERSTANDING OF SMP STUDENT

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Abstract

The design of this study was quasi experimental with a post-test only control group design. Simple random sampling technique was used to get the sample. Data were analyzed using descriptive statistics and MANOVA one way.

The results showed that students who studied through inquiry based learning with formative assessment feedback are different with the students who studied through direct instruction. The conceptual understanding of students who studied inquiry learning with formative assessment feedback were different from students who studied direct instruction. In addition, critical thinking skill and conceptual understanding of students who studied through inquiry based learning with formative assessment feedback differences with students who studied through direct instruction.
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Key words: inquiry based learning, formative assesment feedback critical thinking skill, conceptual understanding

INTRODUCTION

Natural Sciences (IPA) is a science that is obtained by using scientific measures in the form of scientific method and is obtained from the result of experiment or observation or knowledge related to the way of dicovering the nature systematically. According to BSNP (2006), natural science education emphasizes the competencies to enable students to explore and to understand the universe scientifically, so it is expected that the science education, especially in SMP / MTs can be a vehicle for students to learn about themselves and the natural surroundings.

Chemistry as a branch of science is the science that specifically studies about the changes in material, either chemical or physical. The essence of chemistry includes products and processes. Chemistry as product includes knowledge of facts, concepts, and principles, while the process covers the skills and attitudes of the scientists. Thus in learning chemistry is not enough just to do with the provision of facts or concepts, but through a process of discovery. Students are trained to find the facts and concepts, thus it leads to a developing of the capacity to think. Science learning should foster scientific skills which is process skill (science process skills), thinking skills (thinking skills) which means creative thinking and critical thinking, as well as to foster a scientific attitude (scientific attitude) (Curriculum Development Centre Ministry of Education Malaysia, 2002). These skills will help students in finding or gaining knowledge and deeper understanding of the material of science being pursued.

Based on preliminary studies on several junior high schools in the city of Pontianak and discussion with science teachers in the MGMP, it was found that in the chemistry leaerning process, discussion method and assignments with student worksheets contained in the summary of science textbooks are commonly used. Students are not trained to develop the ability to think in finding a concept, build knowledge, and actively participate in the learning process. Teachers rarely engage students for practices, for the reasons of time constraints and insufficient availability of tools and materials. Yet through the practice, students are trained to find the knowledge by fully engaging in practical activities, starts from planning and practice, finding the facts, collecting data, and solving problems in a real situation.

In the instructional of science should cultivate scientific skills which are science process skill, thinking skill that includes creative thinking and critical thinking, and scientific attitude as well (Ministry of Education Malaysia, 2002). Those skills will help students in seeking or finding the knowledge and deeper understanding in science subject they learn.

The seeking skill in order to find the knowledge can be called as inquiry skill (BSNP, 2006). Inquiry is the series of activity which include observation, questioning, testing information from the text book and other sources to see what is known, planning an investigation, reviewing what is known in experimental data, using tools to collect, analyze, and interpret the data, answering the question, the explanation and the prediction, and communicating the result (NRC, 1996). Inquiry is one of the process to obtain or achieve information by observation or experiment to seek the answer or solve the problem of a question or problem by using logic and critical thinking (Jauhar, 2011). Therefore, in the instructional of science, in chemistry specifically, is better directed for inquiry and acting in order to help the students to get the experience and deeper understanding about the nature.

The fact in instructional, in chemistry specifically, there are more teachers that only give the knowledge to the students through lecture, discussion, and task given without practices and scientific work. As the result, knowledge the students get occurs before practicing and not based observation data or practices. It certainly cannot be allowed to drag on because the instructional of science is emphasizing in direct experience to develop students' competence in order to understand the nature from inquiry process. Therefore, the instructional of science cannot be separated from inquiry process. Through inquiry based learning in chemistry, the students is involved in science investigation from direct experience as well as be given chance to take action and work systematically in instructional, so that the students are capable to do the tasks in the real life.

Inquiry is one of the important components in instructional and appropriate to be used in the reformation of instructional of science nowadays (Wenning, 2011). Inquiry based learning has five steps in its instruction. Every steps of inquiry is related with intellectual and science process skill. Every steps is related with five activities that revolves around the students which are observation, manipulation, generalization, verification and application (Wenning, 2011).

There are many facts shows the privilege of inquiry as a model and instructional strategy. The research of Kubicek (2005) concludes that the students with inquiry group can increase their understanding, so that the concept can be acquired better. Another similar research done by Bilgin (2009) shows that student with guided inquiry group cooperatively has a better understanding for the mastery of the material and shows a positive attitude in teaching learning process. However, there are many teachers still have objection or do not want to implement it in the classroom. Most of the teachers and lecturers still stand in traditional way of teaching, because assume that inquiry is difficult instructional strategy to be used (Straits & Wilke, 2005). Adisendjaja (2008) argues that most of SMP students are concrete thinker, so it will be difficult to implement inquiry in abstract concept of chemical. The more habitual the activity, material, and context of the investigation, the easier it is learned through inquiry. Zohar (1994) stated that critical thinking skill can be developed through the study of daily activity.

The questions in the instructional of science can improve the quality of the instructional, because it is driven by the inquiry (curiosity) of the students (Rustaman, 2002). The interview result of the teachers found that one of the causes is the unfamiliarity of the chemistry teacher in SMP in implementing scientific work. Questioning skills are rarely developed by science - chemistry teacher in class because the teacher thinks a lot to cause problems, even though the teacher considers the question is very important to develop the curiosity of students. The ability of the teacher to ask in every step of inquiry is necessary, because the teacher inquiry also can develop a critical attitude of learners.

Inquiry is the art of science asked about various things and find answers to the questions raised. Inquiry learning is not always easy for all students, therefore it is deemed necessary in providing feedback on formative assessment. Feedback is information about how student performance related to goals and standards. A student can monitor any activity and involvement in learning tasks and assess the progress of learning to achieve goals (Nicol & Macfarlane- Dick, 2006). Formative assessment is defined as an assessment conducted during the learning process which refers to the students' progress and understanding. The purpose is to identify learning needs and adjust appropriately learning (OECD, 2005).

Feedback is part of the recitation. Recitation is an approach to teaching in which the teacher provides information, asking questions, get students to respond, and then provide feedback to the praise or, correcting students' understanding of a particular concept. Recitation can be used to strengthen or develop the concept of students (Arends, 2012). In many of universities in America, one of them is in Rutgers University, recitation is intended as a deepening study (Kohl *et al*, 2007). Meanwhile, according to Pollock (2009), recitation is the additions of exercise tutorial by lecture assistants. With the recitation, it can provide an opportunity for seniors to teach, provide feedback, and reflection (Etkina, 2010). It is also supported by research by taking a sample of 330 students at Iowa State University who conducted by Ogilvie (2009) the study found that the use of recitation can develop a conceptual understanding of the material and can improve problem solving skills in students. Inquiry-based learning with feedback formative assessment is expected to boost the quality of learning, understanding of concepts and critical thinking of students on acid-base material in the junior class VII.

Formative assessment feedback can be given by the teacher in the form of information, sign or level / position, written or oral comments on the individual assessment tasks, explanations to the group or class, giving examples of answers to each question (especially the student questions relating to the case / the problem). For students who make mistakes / difficulties, teachers should help how to solve their problems. Instructions or advice can be given teacher in verbal or written form. of the work of students, teachers can provide feedback in the form of comments on the work, suggestions or comments regarding the results of their work improvement. Feedback of the issues that are controversial, arguments that at first glance seems logical but contrary to the theory will practice the skills and critical thinking skills of students.

According to Kunandar (2007), the benefits of the use of inquiry learning strategy is spurring the need for students to learn, motivate them to continue the work that they find answers and students learn to identify problems independently with critical thinking skills. benefits for students in inquiry learning is students will understand the basic concepts and ideas better, help in using memory and transfers in situations of new learning process and are able to develop students' critical thinking skills. For example, when students ask questions, the teacher does not directly answer the questions of students. Students are given the opportunity to provide answers or discussion with colleagues. Comments come from various parties so that the interaction between teachers and students, and students with students. Through discussions like this, which asks students will find answers on a variety of things and build concept at every step of inquiry

with the help of feedback.

Based on the study above, the research on inquiry-based learning with assessment formative feedback to improve student critical thinking skills and understanding of chemistry concepts in junior high. The purpose of this study was to determine differences between groups critical thinking skills students learn in inquiry-based learning with formative assessment feedback in study compared a group of students use direct intruction, understanding the concept between group of students who learn by inquiry learning with feedback on formative assessment compared to the group of students use direct learning, and critical thinking skills and conceptual understanding between groups of students who study in guided inquiry learning with formative assessment feedback comparison with a group of students who learn in direct instruction.

RESEARCH METHOD

Experimental method was used to evaluate the effect of independent variables (Gall, Gall and Borg, 2003). Experimental method varies several conditions and observes their effects againts others (McMillan and Schumacher, 1993). Experimental method can be interpreted as a research method used to search for a specific treatment effect (independent variable) against the other under controlled conditions (Sugiyono, 2011). The independent variables in this study are inquiry-based learning with formative assessment feedback as experiment group treatment and direct instruction as control group treatment. The dependent variables are critical thinking skills and concepts comprehension. Therefore, experimental methods was used to determine the influence of independent variables on dependent variables. In this study, all variables and experimental conditions can not be controlled strictly, so this study is categorized as a quasi-experimental research (Nazir, 2003).

The research design used was a pretest-posttest nonequivalent control group. In accordance with this plan, there were two groups. They were a control group and an experimental group. Control group would be taught with direct instruction, while the experimental group would be taught with inquiry-based learning with formative assessment feedback.

Population was all seventh grade students of SMP 11 Pontianak. Simple random sampling was used to get sample. Instrument used in this study were comprehension test, and critical thinking test. Descriptive statistics and one way multivariate Analyze of Variance (MANOVA) was used to test hypothesis. Before testing the hypothesis, *Kolmogorov-Smirnov* test was used to test normality and *Levene's Test of Equality of Error Variance* was used to test homogeneity.

RESULT AND DISCUSSION

1. Differences of Critical Thinking Skills and Conceptual Understanding Between Students Taught Through Inquiry Based Learning with Formative Assesment Feedback and Direct Instruction

Based on data collection and analysis of research that has been conducted, it was found differences in critical thinking skills and conceptual understanding between students who learn through inquiry-based learning with formative assessment feedback and direct instruction. This result was based on a statistical test by Pillai Trace MANOVA, Wilk's Lamda, Hotelling's Trace and Roy's Largest Root found the value of significance = 0.000 and the value is less than 0.05 ($p < 0.05$). Previous results of the test for normality using the Kolmogorov-Smirnov, it was acquired that significance value was greater than 0.05. These results indicate that the data derived from normally distributed population. Furthermore, the result of Levene's Test of Equality of Error Variances on critical thinking data was significantly greater than 0.05. These results indicate that the data of critical thinking skills and understanding of the concept had homogeneous data variance.

Hypothesis test results show that the implementation of inquiry-based learning with

formative assessment feedback was better than direct instruction in term of improving critical thinking and understanding of the concept. This happens because the inquiry learning allows students to engage actively using physical process of finding some concepts being studied themselves. Students were given the opportunity to participate in learning and teacher guide them only. So the knowledge and skills acquired by students was not result of remembering the facts, but finding the concept themselves. Teacher acted as facilitators. Thus the inquiry-based learning would improve critical thinking and understanding of the concept of students. According to Bilgin (2009), it was found that students who learn through guided inquiry learning cooperatively have a better understanding of mastering subject matter concepts and demonstrate a positive attitude in learning

In inquiry-based learning, students could be actively involved in scientific activities. Students might have the opportunity to observe, inquire, explain, design and test a hypothesis that can be optimally involved the student's ability to seek and investigate in a systematic, critical, logical, and analytical way, and formulate their own inventions. As stated before, Amilasari and Sutiadi (2008) stated that the inquiry learning can improve scientific thinking that placing students as learners in solving problems and acquiring knowledge so students can understand scientific concepts. In the concluding stage of inquiry learning, students thought about what conclusions can be drawn in the study, and the other students had to provide feedback. Students' critical thinking skills will be sharpened and students are able to master the concepts taught.

For students who had difficulty in conducting an inquiry on the abstract chemistry concept chemistry can be overcome with formative assessment feedback at every stage of the inquiry, so that more developed the students' desire and motivation to learn the principles and chemistry concepts, as well as developed students' critical thinking. The results also showed that the feedback given in the learning and after the learning process was part of the recitation can be used to strengthen or develop the concept of students. A study on 330 students at Iowa State University who conducted by Ogilvie (2009) found that the use of recitation can develop a conceptual understanding of the material and can improve college students' problem solving skills. This recitation was given after the learning process. A study conducted by Hairida (2013) about formative assessment feedback show that there were significant interactions between giving feedback and eficacy themselves against science-chemistry learning outcomes, after controlling student intelligence. Student learning outcomes that were given a feedback was better. Thus, the provision of feedback in learning science (chemistry) based inquiry reinforce students' understanding and critical thinking.

In contrast with what stated above, the control group using conventional learning (direct instruction). Teachers do, show, and present/demonstrate more about a process, so that students have less understanding about the teacher's explanation. Teachers have dominant role in learning. Arends (2012) states: "Direct instruction is a teacher-centered models that has five steps: establishing a set, explanation and / or demonstration, guided practice, feedback, and extended practice a direct instruction lesson requires careful orchestration by the teacher and a learning environment that businesslike and task-oriented ". So in direct instruction, teachers must demonstrate the knowledge and skills that will be trained to students, step by step. Students learn by observing selectively, remember and imitate what the teacher modeled. This kind of instruction affect students mind, and make it undeveloped, because students were not given the opportunity to discover or explore their abilty themselves in learning. Thus there is a difference in critical thinking skills and understanding of concepts between students who learn through inquiry-based learning with formative assessment feedback and direct instruction.

2. Differences of Critical Thinking Skills Between Students Taught Through Inquiry Based Learning with Formative Assessment Feedback and Students Taught Through Direct Instruction

Based on data collection and analysis that has been carried out, that is found that average pretest of students' critical thinking skills in inquiry learning with formative assessment feedback is 36.29 and average of posttest is 73.79 with an average of difference between pretsest - posttest is 37.70. While the average of pretest of students' critical thinking skills on direct instruction is 36.03 and average of posttest is 63.82 with an average of difference of pretest-posttest is 27.79. Based on average of difference of the learning data, it shows that the average of difference of students' critical thinking on inquiry-based learning with formative assessment feedback is better than direct instruction.

Based on normality test of Kolmogorov-Smirnov, it is faund that the significance value is 0.200. it is greater than 0.05. This indicates that the data of students' critical thinking skills (pretest and posttest) is derived from the normally distributed population. Furthermore, the homogeneity of variance using Levene's Test of Equality of Error Variances has a significance value. It is 0.690 which is greater than 0.05. These results indicate that the data of students' critical thinking skills (pretest and posttest) has a homogeneous data variance. Furthermore, the results obtained by testing the hypothesis using F test shows F = 40.435 with a significance of 0.000. it is less than 0.05, then Ho is rejected. It was concluded that there is a difference between groups of students critical thinking that learning through inquiry-based learning with formative assessment feedback with direct instruction.

According to Gulo (2005), inquiry model is a series of learning activities that involve maximally throughout the student's ability to seek and investigate in a systematic, critical, logical, and analytical ways, so that students can formulate their own discoveries with confidence. So learning is not just to remember facts, but learning is the process of thinking. Lawson (2000) stated that the activities of inquiry can train students' thinking skills and improve their skills in solving problem. So in inquiry learning, critical thinking skills of students in conducting the investigation are very high.

The research findings indicate that involvement, active participation, and critical thinking skills of students in the investigation are very high. Student difficulties in implementing the phases of inquiry can be overcome by giving formative assessment feedback, so that the active involvement of students in the learning process is always maintained. The main purpose of inquiry-based learning is to develop student scientific skills and preparation for long life learning. Through this learning, students will have critical thinking, the ability for independent inquiry, responsibility for own learning and intellectual growth and maturity (Lee, *et al*., 2004). Kazempour (2013), conclude that inquiry based learning affect critical thinking skills. Students have the opportunity to learn how to find the facts, concepts, and principles directly or train students in developing scientific skills. The subject matter is not given directly by the teacher, but the students find subject matter themselves, while the teacher acts as a facilitator and mentor students to learn. This provides an opportunity for students to optimize its capabilities through direct involvement in the learning process, so it affects the students' critical thinking skills.

In contrast with what stated before, in direct instruction, students were not involved directly on process of finding the facts, concepts, or principles. Teachers involved more actively in learning process. According to Mujis & Reinolds (2008), direct instruction was also known as active learning or whole class teaching which adopt of teaching style that teachers involved actively in delivery concepts to students by teaching them directly. Students were not involved in developing knowledge and understanding concepts as scientis do. It results the difference of critical thinking skills between students taught through inquiry based learning with formative assessment feedback and students taught through direct instruction.

3. Differences of Conceptual Understanding Between Students Taught Through Inquiry Based Learning with Formative Assessment Feedback and Students Taught Through Direct Instruction

Based on data analysis, it is found that the average of conceptual understanding pretest of students taught through inquiry based learning with formative assessment feedback is 37.91 and the average of posttest is 75.65 with average of pretest-posttest difference is 37.74. While the average of conceptual comprehension pretest of students taught through direct instruction is 37.24 and the average of posttest is 65.94 with the average of pretest-posttest difference is 28.70. As stated before, it shows that the average of difference in the students' conceptual understanding of inquiry-based learning with formative assessment feedback is better than direct learning

Based on normality test result using the Kolmogorov-Smirnov test, it was found that the significance value is 0.200. It was greater than 0.05. This indicates that the data of student conceptual understanding is derived from populations with normal distribution. Furthermore, based on the homogeneity test using Levene's Test of Equality of Error Variances, it was found that significance value is 0.925 which is greater than 0.05. These results indicate that the students' conceptual understanding data (pretest and posttest) has a homogeneous data variance. Furthermore, the result obtained by testing the hypothesis using F test show that F = 56.533 which has significance value is 0.000. it is less than 0.05, then Ho is rejected. It was concluded that there is a difference between students' conceptual understanding who learn through inquiry-based learning with formative assessment feedback and students' conceptual understanding who learn through direct instruction

An improvement on conceptual understanding in inquiry-based learning with formative assessment feedback can be influenced by an attractive learning environment, because students learn to observe directly the event, making it easier for students to understand the concept. Inquiry learning allows the construction of knowledge by students themselves, so that the acquired knowledge will be meaningful. In contrast to the direct instruction, students' knowledge were given by teachers, through teacher notification, so that knowledge itself is only remembered and easily forgotten. Direct instruction involves a lot of communication between teachers and students, so that teachers will find it hard to know the students' understanding. Teachers provide information, while students just record or pay attention to what is presented and demonstrated by the teacher. The comprehension of concept through the discovery directly did not happen in direct instruction. Some research support that inquiry-based learning can improve students' conceptual understanding. Research conducted by Deur and Harvey (2005) found that the inquiry learning strategy gives a different effect significantly to the understanding of concepts and student learning outcomes. Further research Balim (2009) concluded that learning by using the inquiry give good value on students' cognitive and affective aspects. This has resulted in differences between students' conceptual understanding who learn using inquiry-based learning with formative assessment feedback and students' conceptual understanding taught using direct instruction.

CONCLUSION AND SUGGESTION

Based on the analysis of data can be presented conclusions as follows: 1) There are differences of critical thinking skills and conceptual understanding between students taught through inquiry based learning with formative assesment feedback and direct instruction, because the price of the significance of statistical tests Pillai Trace, Wilk's Lamda, Hotelling's Trace and Roy's Largest Root is 0,000 and this value is smaller than 0.05 ($p < 0.05$); 2) There are differences

in critical thinking between of students who learn through inquiry-based learning with formative assessment feedback and direct instruction (of F = 40.435 and p <0.05); 3) There are differences of conceptual understanding between students taught through inquiry-based learning with formative assessment feedback and direct instruction (of F = 56.533 and p < 0.05).

The advice given related research results as follows: 1) The results proved that inquiry-based learning with formative assessment feedback can improve of critical thinking skills and conceptual understanding the students, so it is a good lesson to be applied in learning. In this lesson the teacher can help students to construct their knowledge, so that students can find their own answers to the problems associated with life. 2) Inquiry based learning with formative assessment feedback proven to improve students' critical thinking skills, but this increase is not maximized. Therefore, in learning these critical thinking skills should be trained continuously, so that students become accustomed to analyze simultaneously solve a problem. Thus the students' critical thinking can be further improved; 3) Conceptual understanding of students through inquiry-based learning with formative assessment feedback proved daapat increased. To that end, this study should be considered as a teacher in supporting the success of the actual achievement of learning objectives, ie not enough students memorize the material, but students find the knowledge itself and really understand it.

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